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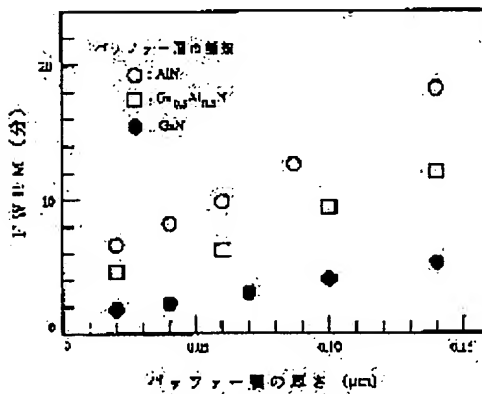
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(54) METHOD FOR GROWING CRYSTAL OF GALLIUM NITRIDE-BASED COMPOUND SEMICONDUCTOR AND GALLIUM NITRIDE-BASED COMPOUND SEMICONDUCTOR

(57)Abstract:

PROBLEM TO BE SOLVED: To improve crystallinity of a gallium nitride-based compound semiconductor grown on a buffer layer, and to stably grow the gallium nitride-based compound semiconductor in a good yield.

SOLUTION: A crystal of the gallium nitride-based compound semiconductor is grown on the buffer layer by a metal organic compound vapor phase growth method. This method for growing the gallium nitride-based compound semiconductor comprises first growing a polycrystalline buffer layer having the formula: $GaXAl_{1-X}N$ (where, X is ≥ 0.5 and ≤ 1), then raising the temperature to partially crystallize the buffer layer to form a single crystal and growing the gallium nitride-based compound semiconductor containing a carrier in a concentration of 2×10^{15} (example 6) to $1 \times 10^{19}/cm^2$ (example 8) by using the



partially crystallized buffer layer as a seed crystal.

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[Claim(s)]

[Claim 1] In the approach of growing up the crystal of a gallium nitride system compound semiconductor on a buffer layer by organometallic compound vapor growth general formula $GaXAl_{1-X}N$ (however, it is the range of $0.5 \leq X \leq 1$ --) Grow up the buffer layer of the becoming polycrystal, next raise temperature, single-crystal-ize a buffer layer selectively, and this is made into seed crystal. The crystal growth approach of the gallium nitride system compound semiconductor characterized by growing up the gallium nitride system compound semiconductor which sets carrier concentration to 2×10^{15} to $1 \times 10^{19} / \text{cm}^2$.

[Claim 2] The crystal growth approach of the gallium nitride system compound semiconductor according to claim 1 characterized by growing up said buffer layer on a gallium nitride system compound semiconductor layer.

[Claim 3] The crystal growth approach of the gallium nitride system compound semiconductor according to claim 1 characterized by doping Si or Mg during said gallium nitride system compound semiconductor layer growth.

[Claim 4] The crystal growth approach of the gallium nitride system compound semiconductor according to claim 1 characterized by the thickness of said buffer layer being 0.2 micrometers or less.

[Claim 5] The crystal growth approach of the gallium nitride system compound semiconductor indicated by claim 1 into which the gallium nitride system compound semiconductor which makes mobility $8.5\text{--}600 \text{ cm}^2/\text{V}\text{--}\text{sec}$ is grown up.

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to the growth approach of the epitaxial layer of a gallium nitride system semiconducting compound which was excellent in especially crystallinity about the approach of growing up the crystal of a gallium nitride system compound semiconductor, on substrates, such as sapphire.

[0002]

[Description of the Prior Art] Recently, the blue luminescence device of $[GaXAl_{1-X}N]$

(however, X is in the range of $0 \leq X \leq 1$.)] attracts attention to the gallium nitride system compound semiconductor, for example, a general formula. As an approach of growing up the crystal of a gallium nitride system compound semiconductor, organometallic compound vapor growth (henceforth the "MOCVD method") is known well. This approach is an approach of supplying organometallic compound gas as reactant gas in the reaction container which installed silicon on sapphire, holding crystal growth temperature at an about 900 degrees C - 1100 degrees C elevated temperature, and growing up the epitaxial layer of a compound semiconductor crystal on a substrate. For example, in growing up a GaN epitaxial layer, it uses ammonia gas as V group gas with trimethylgallium as III group gas.

[0003] Thus, in order to use the epitaxial layer of a gallium nitride system compound semiconductor grown up as a luminescence device, it is indispensable to raise crystallinity in the first place.

[0004] Moreover, using the MOCVD method, on silicon on sapphire, directly, it became a pillar-shaped growth pattern six angles, countless irregularity was made, and, as for the front face of a GaN layer, the shape of a 6 angle pyramid and the fault to which the surface morphology gets very bad grew. Making a blue luminescence device using the crystal layer of the very bad semi-conductor of the surface morphology which has countless irregularity in a front face had the dramatically bad yield, and it was almost impossible.

[0005] in order to solve such a problem, before growing up the crystal of a gallium nitride system compound semiconductor, the method of growing up the buffer layer of AlN on a substrate is proposed -- {- Appl.Phys.Lett 48, (1986), and 353 -- (- applied physics Letters [] -- 48 volumes, 1986, 353-page), and JP,2-229476,A}. On silicon on sapphire, this approach is low temperature with a growth temperature of 400-900 degrees C, and prepares the buffer layer of AlN whose thickness is 100-500A. According to this approach, there is the description which can improve the crystallinity of a GaN semi-conductor layer and surface morphology by growing up GaN on the AlN layer which is a buffer layer.

[0006]

[Problem(s) to be Solved by the Invention] However, since the growth conditions of a buffer layer are restricted severely and said approach moreover needs to set thickness as 100-500A and the very thin range strictly, it is difficult to form the buffer layer in homogeneity by fixed thickness all over a silicon-on-sapphire [of a large area], for example, silicon on sapphire of about 50mmphi, top. Therefore, by the time it made light emitting diode with the crystallinity still practical difficult [it / to improve the crystallinity of a gallium nitride system compound

semiconductor and surface morphology which are formed on the buffer layer with a sufficient yield], semiconductor laser, etc., it did not result, but the further crystalline improvement was required.

[0007] This invention is made in view of such a situation, the place made into the object improves the crystallinity of a gallium nitride system compound semiconductor and surface morphology which are grown up on a buffer layer even on practical use level, a gallium nitride system compound semiconductor is stabilized further, and the growth approach for growing up with a sufficient yield is offered.

[0008]

[Means for Solving the Problem] The crystal growth approach of the gallium nitride system compound semiconductor of this invention improves the approach of growing up the crystal of a gallium nitride system compound semiconductor, by organometallic compound vapor growth. The approach of this invention grows up the buffer layer of the polycrystal which consists of general formula $GaXAl_{1-X}N$ (however, it is the range of $0.5 \leq X \leq 1$). Next, temperature up of the substrate is carried out, and the buffer layer is single-crystal-ized selectively, and it is characterized more nearly further than the growth temperature of said buffer layer by growing up a gallium nitride system compound semiconductor at an elevated temperature.

[0009] Furthermore, the crystal growth approach of the gallium nitride system compound semiconductor of claim 2 of this invention is growing up said buffer layer on a gallium nitride system compound semiconductor layer. The growth approach of the gallium nitride system compound semiconductor of claim 3 has doped Si or Mg during said gallium nitride system compound semiconductor layer growth further again. The growth approach of the gallium nitride system compound semiconductor of claim 4 is setting thickness of said buffer layer to 0.2 micrometers or less further again.

[0010] As shown in drawing 4 - drawing 6 , 0.002 micrometers or more of 0.2 micrometers or less of said buffer layer thickness are preferably adjusted to the range of 0.01-0.2 micrometers still more preferably. When the thickness is thinner than 0.002 micrometers and thicker than 0.2 micrometers, it is in the inclination for the surface morphology of the crystal of the gallium nitride system compound semiconductor formed on a buffer layer to worsen.

[0011] moreover, the growth temperature of said buffer layer -- 200 degrees C or more 900 degrees C or less -- desirable -- 400-800 degrees C -- range adjustment is carried out. If lower than 200 degrees C, it will be hard to form a buffer layer, and

when higher than 900 degrees C, a buffer layer is in the inclination to become a single crystal and to stop achieving the operation as a buffer layer mentioned later.

[0012]

[Function] GaXA11-XN is made into a buffer layer at drawing 1, the sectional view showing the structure of the epitaxial wafer at the time of growing up the crystal of a gallium nitride system compound semiconductor on it is shown, and the sectional view showing the structure of the epitaxial wafer at the time of growing up the crystal the same and same on it is shown by making AlN into a buffer layer at drawing 2. Compared with the conventional buffer layer, since the tolerance of thickness is large, the buffer layer of this invention can grow a buffer layer and a gallium nitride system compound semiconductor crystal with a sufficient yield.

[0013] By the way, the method of growing up the crystal of a gallium nitride system compound semiconductor by making AlN into a buffer layer Thin Solid Films.163, (1988), 415 (SHIIN solid films 163 volumes) Although stated to 415 pages and Appl.Phys.Lett 48, (1986), 353 (applied physics Letters 48 volumes, 1986, 353 pages), etc. in detail in 1988 They are the following contents when an operation of the buffer layer indicated by those reference is described briefly.

[0014] AlN grown up at low temperature (about 600 degrees C) is a polycrystal layer, and in case it raises temperature even to about 1000 degrees C in order for this buffer layer to grow up GaN, a layer single-crystal-izes it selectively. When the part single-crystal-ized selectively grows up GaN at 1000 degrees C, it serves as seed crystal to which bearing was equal, a GaN crystal grows from the seed crystal, and a uniform GaN single crystal layer can be grown up. Since silicon on sapphire itself serves as seed crystal when there is no buffer layer, bearing is the content that the crystal of the hexagonal prism of GaN which varied greatly will grow.

[0015] It is GaXA11-XN ($0.5 \leq X \leq 1$) like this invention. It is considered in the conventional AlN that the case where it forms as a buffer layer is as follows as compared with the case where it considers as a buffer layer.

[0016] When the case where GaN of $X = 1$ is formed as a buffer layer is considered first, the melting point of GaN is 1100 degrees C, and the melting point of AlN is 1700 degrees C. For this reason, if the buffer layer of GaN is formed at 600 degrees C, the buffer layer of polycrystal will grow. Next, in order to grow up the epitaxial layer of GaN on the GaN buffer layer of this polycrystal, when temperature is raised to 1000 degrees C, the buffer layer of GaN will be single-crystal-ized selectively, and it will act as seed crystal for GaN epitaxial layers like the case where AlN is made into a buffer layer.

[0017] And since the ** melting point is lower than the case where AlN is formed as

a buffer layer, while going up temperature, it is [single-crystal-] easy to make easily. For this reason, even if it thickens buffer layer thickness, the effectiveness as a buffer layer is expectable.

** Since a buffer layer is GaN, when growing up the epitaxial layer of GaN on it, since the same ingredient is grown up on the same ingredient, crystalline improvement can be expected. It is thought that there is an advantage of **.

[0018] in order to check the above thing -- AlN and Ga_{0.5}Al_{0.5}N -- three kinds of buffer layers of AlN and GaN are formed on silicon on sapphire at 600 degrees C, respectively, and drawing which asked for the relation between the mesial magnitude width (FWHM:full width at half-maximum) of the double crystal X-ray rocking curve of a GaN epitaxial layer at the time of growing up a GaN epitaxial layer by the thickness of 4 micrometers by 1000 degrees C on it and the thickness of a buffer layer is expressed to drawing 3. Crystallinity of FWHM is so good that it is small.

[0019] As shown in drawing 3, what was made into the buffer layer of GaN and Ga_{0.5}Al_{0.5}N has good crystallinity in the thickness range of a large buffer layer, and shows the property which was extremely excellent as compared with the buffer layer of the conventional AlN.

[0020] The thickness of the GaN buffer layer formed on silicon on sapphire is changed into drawing 4 - drawing 7, and microphotography drawing showing the crystal structure of the front face of a GaN epitaxial layer at the time of growing up 4 micrometers of epitaxial layers of GaN on it further is shown. In order, buffer layer thickness is 0.002 micrometers, 0.07 micrometers, 0.20 micrometers, and 0 micrometer (with no buffer layer) from drawing 4 to drawing 7.

[0021] When there is no buffer layer so that it may understand, even if it sees these drawings, as drawing 7 shows, a pillar-shaped crystal appears six angles in a front face. Although based also on the conditions at the time of forming a buffer layer, there is an inclination for a front face to become mirror plane homogeneity as a buffer layer is formed. However, when a buffer layer is too thick, it is in the inclination for a surface condition (surface morphology) to worsen. Therefore, desirable buffer layer thickness is for 0.01 to 0.2 micrometers.

[0022] Moreover, as long as the buffer layer by the crystal growth approach of this invention is a layer which has the epitaxial layer of not only a silicon-on-sapphire top but a gallium nitride system compound semiconductor, it may be formed in any layer. For example, a buffer layer can be formed on said n mold GaN epitaxial layer and a p mold GaN epitaxial layer can also be grown up on the buffer layer to form the epitaxial layer of the p mold GaN with which Mg which is p mold impurity was

doped on an n mold GaN epitaxial layer.

[0023]

[Example] Hereafter, the example of this invention is explained. However, the example shown below does not illustrate the approach for materializing the technical thought of this invention, and the approach of this invention does not specify growth conditions, the class of organometallic compound gas, the material of construction, etc. as the following. The growth approach of this invention can add various modification in a claim.

[0024] Crystal growth of a gallium nitride system compound semiconductor was performed using the equipment shown in drawing 8 .

[Example 1] The epitaxial layer of GaN was grown up into silicon on sapphire by 4-micrometer thickness at the following process.

** Carry the silicon on sapphire of washed 2 inch phi on a susceptor 2.

** Permute the interior by H₂ further after exhausting the air in the reaction container 1 made from stainless steel with the exhaust air pump 6.

** Heat a susceptor 2 to 1060 degrees C at a heater 3, supplying H₂ gas in the reaction container 1 after that from the reactant gas injection pipe 4 and the subinjection pipe 5 of the reaction container 1 upper part.

** Hold this condition for 10 minutes and remove the oxide film on the front face of silicon on sapphire.

** Next, lower the temperature of a susceptor 2 to 500 degrees C, and put until temperature is stabilized.

** Supply the mixed gas of H₂ and N₂ from the subinjection pipe 5 continuously, and supply the mixed gas of ammonia gas and H₂ gas from the reactant gas injection pipe 4. The flow rate of the ammonia gas which supplies the flow rate of H₂ gas supplied from the subinjection pipe 5 and N₂ gas from a part for 1/ and the 10l. reactant gas injection pipe 4, respectively considers the flow rate of a part for 4l./, and H₂ gas as a part for 1l./, and it waits for it until the temperature of a susceptor 2 is stabilized at 500 degrees C in this condition.

** in order to form a buffer layer after that -- the reactant gas injection pipe 4 to ammonia gas, and H₂ gas -- in addition, pass TMG (trimethylgallium) gas for 1 minute by part for 2.7x10⁻⁵-mol/.

** Next stop only TMG gas and stop growth of a buffer layer. The buffer layer of 0.02 micrometers of thickness can be formed here. The gas of further others raises the temperature of a susceptor 2 to 1000 degrees C with a sink.

** the reactant gas injection pipe 4 after the temperature of a susceptor 2 rises to 1020 degrees C to ammonia gas, and H₂ gas -- in addition, TMG gas -- 5.4x10⁻⁵ a

mol -- it supplies for 60 minutes by the flow rate for /, and a GaN epitaxial layer is grown up by 4.0-micrometer thickness.

In the meantime, supplying H₂ and N₂ gas from the subinjection pipe 5 is always continued on condition that the above-mentioned, and the inside of a reaction container is made not to be polluted with reactant gas. Moreover, a susceptor 2 makes it rotate by 5rpm by the motor 7 so that a crystal may grow up to be homogeneity. In addition, although it is natural, while supplying gas, the gas currently supplied is emitted to the exterior from piping of the exhaust air pump 6, and the branched exhaust pipe 8. As mentioned above, the GaN buffer layer of 0.02 micrometers of thickness was grown up on silicon on sapphire, and the 4-micrometer GaN epitaxial layer was grown up on it.

[0025] In the process which forms the buffer layer of [example 1 of comparison] **, the 4-micrometer GaN epitaxial layer was grown up on the AlN buffer layer like the example 1 except forming the buffer layer of AlN by 0.02-micrometer thickness. In addition, when forming an AlN buffer layer, in addition to ammonia gas and H₂ gas, in **, TMA (trimethylaluminum) was passed for 1 minute by part for 2.7×10^{-5} mol from the reactant gas injection pipe 4.

[0026] Hole measurement after growth is performed at a room temperature, it asks for the carrier concentration and mobility of the GaN epitaxial layer by this invention, and the GaN epitaxial layer by the example 1 of a comparison, respectively, and drawing showing the field interior division cloth of the carrier concentration by the result and mobility is shown in drawing 9 and drawing 10 . - shows drawing 10 and carrier concentration and this invention shows mobility for drawing 9 and the example of a comparison by O.

[0027] When growing up the crystal of a non dope, it expresses that crystallinity is so good that carrier concentration is small and mobility is moreover large, and high impurity concentration is small.

[0028] As shown in drawing 9 , as for GaN by this invention, carrier concentration shows a value with very as sufficient 4×10^{16} /cm³ and mobility as 600cm²/V-sec. On the other hand, carrier concentration was [1×10^{18} /cm³ and the mobility of the example 1 of a comparison which made AlN the buffer layer] about 90cm²/V-sec.

[0029] In the process which forms the buffer layer of [example 2] **, the buffer layer of Ga_{0.5}aluminum_{0.5}N was formed by 0.02-micrometer thickness, and the GaN epitaxial layer was grown up on the buffer layer like the example 1 except not considering a buffer layer and a gallium nitride system compound semiconductor as the same presentation. In addition, when forming a buffer layer, from the reactant gas injection pipe 4, in addition to ammonia gas and H₂ gas, TMG was

passed by part for 2.7×10^{-5} mol/l, and TMA was passed for 0.5 minutes by part for 2.7×10^{-5} mol/l, respectively. As this GaN epitaxial layer was also shown in drawing 3, the outstanding X-ray rocking curve was shown, and the surface morphology by microscope observation was that to which an example 1, equivalent and carrier concentration, and mobility are located in the medium of an example 1 and the example 1 of a comparison.

[0030] In [example 3] **, made growth temperature of a buffer layer into 600 degrees C, and changed the gas stream time amount of ** in 2.5 minutes, and thickness of a buffer layer was set to 0.05 micrometers, and also the GaN epitaxial layer was grown up like the example 1. This GaN epitaxial layer also showed 3 minutes and the outstanding crystallinity, and an example 1, an EQC, and its mesial magnitude width of an X-ray rocking curve were [surface morphology] equivalent to the example 1 also with carrier concentration and mobility.

[0031] Growth temperature of a buffer layer was made into 800 degrees C in [example 4] **, and also the GaN epitaxial layer was grown up like the example 1. This GaN epitaxial layer also showed 3 minutes and the outstanding crystallinity, and an example 1, an EQC, and its mesial magnitude width of an X-ray rocking curve were [surface morphology] equivalent to the example 1 also with carrier concentration and mobility.

[0032] In the process which forms the buffer layer of [example 5] ** on the same conditions as an example 2 Form the buffer layer of Ga_{0.5}aluminum_{0.5}N by 0.02-micrometer thickness, and it sets to **. From the reactant gas injection pipe 4, in addition to ammonia gas and H₂ gas, supply TMA gas by part for 2.7×10^{-5} mol/l, and TMG gas is supplied for 60 minutes by 2.7×10^{-5} mol the flow rate for /. A Ga_{0.5}aluminum_{0.5}N epitaxial layer is grown up by 4.0-micrometer thickness, and also the 4-micrometer Ga_{0.5}aluminum_{0.5}N epitaxial layer was grown up on it with the Ga_{0.5}aluminum_{0.5}N buffer layer of 0.02 micrometers of thickness on silicon on sapphire like the example 1. This Ga_{0.5}aluminum_{0.5}N epitaxial layer of surface morphology was also equivalent to the example 1.

[0033] In [example 6] **, in addition to ammonia gas, H₂ gas, and TMG gas, Mg which is the impurity of p mold with a sink about Cp₂Mg (bis(cyclopentadienyl) magnesium) gas at a GaN epitaxial layer was doped, and the p mold GaN epitaxial layer was grown up by 4.0-micrometer thickness. The p mold GaN epitaxial layer of 4.0 micrometers of thickness which doped the GaN buffer layer of 0.02 micrometers of thickness on silicon on sapphire, and doped Mg 10^{20} /cm³ on it as mentioned above was grown up. This p mold GaN epitaxial layer is also equivalent to an example 1, and, as for surface morphology, showed p mold property for the first

time with 2.0×10^{15} /of carrier concentration cm^{-3} , mobility of $9.4 \text{ cm}^2 / \text{V-sec}$, and a gallium nitride system compound semiconductor. This shows that the crystallinity of this epitaxial layer is dramatically excellent.

[0034] On the GaN epitaxial layer of 4 micrometers of thickness obtained in the [example 7] example 1, the p mold GaN epitaxial layer of 4.0 micrometers of thickness which doped $\text{Mg } 10^{20}/\text{cm}^3$ the GaN buffer layer of 0.02 micrometers of thickness and on it like the example 6 was grown up. This p mold GaN epitaxial layer is also equivalent to an example 1, and, as for surface morphology, showed p mold property. [as well as 3.5×10^{15} /of carrier concentration cm^{-3} , and mobility of $8.5 \text{ cm}^2 / \text{V-sec}$]

[0035] Si which is the impurity of n mold with a sink about silane (SiH_4) gas at a GaN epitaxial layer was doped, and it was made to grow up by 4.0-micrometer thickness in [example 8] ** in addition to ammonia gas, H_2 gas, and TMG gas. The n mold GaN epitaxial layer of 4 micrometers of thickness which doped the GaN buffer layer of 0.02 micrometers of thickness on silicon on sapphire, and doped Si about $10^{20}/\text{cm}^3$ on it as mentioned above was grown up. This n mold GaN epitaxial layer is also equivalent to an example 1, and, as for surface morphology, showed 1.0×10^{19} /of carrier concentration cm^{-3} , and very high carrier concentration.

[0036] [Example 2 of a comparison] Except forming the buffer layer of AlN by 0.02-micrometer thickness, Si was doped like the example 8 and the 4 more-micrometer n mold GaN epitaxial layer was grown up on the AlN buffer layer formed on silicon on sapphire. It is thought that the carrier concentration whose n mold GaN epitaxial layer of this is $5.0 \times 10^{18}/\text{cm}^3$ and whose carrier concentration is about one example of a comparison is not obtained, but is compensated with an impurity, and is low.

[0037]

[Effect of the Invention] As explained above, it is $\text{GaXAl}_{1-X}\text{N}$ ($0.5 \leq X \leq 1$). By forming in a buffer layer, the crystallinity of the gallium nitride system compound semiconductor grown up on it improves by leaps and bounds. Especially the crystal growth approach of the gallium nitride system compound semiconductor of this invention specifies the value of X of $\text{GaXAl}_{1-X}\text{N}$ which is a buffer layer as the range of $0.5 \leq X \leq 1$, and is characterized by growing up a buffer layer further within the reaction container into which a gallium nitride system compound semiconductor is grown up. By pinpointing the range of X of a buffer layer in the range of $0.5 \leq X \leq 1$, the crystal growth approach of the gallium nitride system compound semiconductor of this invention can improve FWHM remarkably rather than the gallium nitride system compound semiconductor which uses the

conventional AlN for a buffer layer, as shown in drawing 3 . FWHM is a parameter which shows crystallinity. therefore, the thing for which the approach of this invention grows up a buffer layer and a gallium nitride system compound semiconductor within the same reaction container -- in addition, the extremely excellent features most important for the approach of growing up the crystal of a gallium nitride system compound semiconductor that crystallinity is remarkably improvable are realized by pinpointing the range of X in $0.5 \leq X \leq 1$. Carrier concentration and mobility are also the parameters which show crystallinity. When growing up the crystal of a non dope, it expresses that crystallinity is so good that carrier concentration is small and mobility is moreover large, and high impurity concentration is small. As the gallium nitride system compound semiconductor made as an experiment in the example 1 of this invention is shown in drawing 9 , in hole measurement of a crystal, carrier concentration shows the extremely excellent value of $4 \times 10^{16} / \text{cm}^3$, and mobility of $600 \text{ cm}^2 / \text{V} \cdot \text{sec}$. This value is a value which was excellent by leaps and bounds in the gallium nitride system compound semiconductor crystal. Carrier concentration is [$1 \times 10^{18} / \text{cm}^3$ and the mobility of the gallium nitride system compound semiconductor incidentally manufactured by the conventional approach of making AlN a buffer layer] about $90 \text{ cm}^2 / \text{V} \cdot \text{sec}$. Carrier concentration is excellent and the gallium nitride system compound semiconductor which carried out crystal growth by the approach of this invention is excellent in mobility also about 7 times 100 or more times. Furthermore, when the crystal growth approach of the gallium nitride system compound semiconductor of this invention forms a buffer layer, processing of what also shows [the GaN epitaxial layer which doped Mg grown up on it] p mold nothing. This is the first thing and completely shows how the crystallinity of the gallium nitride system compound semiconductor grown up by the approach of this invention is excellent. Moreover, the n mold GaN which doped Si grown up on the buffer layer also shows very high carrier concentration as compared with what made AlN the buffer layer. Compared with the conventional AlN buffer layer, the conditions for growing up a buffer layer by the approach of this invention are loose further again. That is, the crystallinity of the gallium nitride system compound semiconductor layer grown up on it is good in the range where the thickness of a buffer layer is large. For this reason, it excels in the mass production nature at the time of forming a light emitting device. Thus, by using the technique of this invention, the application has a very large thing towards utilization to semiconductor laser not to mention blue light emitting diode using the crystal of a gallium nitride system compound semiconductor.

[Brief Description of the Drawings]

[Drawing 1] The outline sectional view showing the structure of the epitaxial wafer by the crystal growth approach of this invention

[Drawing 2] The outline sectional view showing the structure of the epitaxial wafer by the conventional crystal growth approach

[Drawing 3] Drawing showing the relation between the mesial magnitude width (FWHM) of the double crystal X-ray rocking curve of a GaN epitaxial layer, and the thickness of a buffer layer

[Drawing 4] Microphotography drawing showing the structure of the crystal of a GaN epitaxial layer

[Drawing 5] Microphotography drawing showing the structure of the crystal of a GaN epitaxial layer

[Drawing 6] Microphotography drawing showing the structure of the crystal of a GaN epitaxial layer

[Drawing 7] Microphotography drawing showing the structure of the crystal of a GaN epitaxial layer

[Drawing 8] The partial outline sectional view of the equipment used for this invention

[Drawing 9] Drawing showing the field interior division cloth of the carrier concentration by the hole measurement result of the GaN crystal by the approach of this invention, and mobility

[Drawing 10] Drawing showing the field interior division cloth of the carrier concentration by the hole measurement result of the GaN crystal by the conventional approach, and mobility

[Description of Notations]

1 -- Reaction container

2 -- Susceptor

3 -- Heater

4 -- Reactant gas injection pipe

5 -- Subinjection pipe

6 -- Exhaust air pump

7 -- Motor

8 -- Exhaust pipe